An LF receiving converter with loop-stick antenna

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Interest in exploring low frequency (LF) techniques has been re-kindled in this country by the likely approval for Australian Advanced amateur licensees to use 135.7 to 137.8 kHz (2,200 metres) for narrow-band modes.

Unfortunately, most households and/or neighbourhoods are now enveloped in an 'electronic smog' of spurious noise plus a galaxy of harmonics from a multitude of switch-mode power supplies and other appliances. Rather than use the main transmitting antenna for receiving, much better results should be obtained where a loop, either 'frame' style, or ferrite rod (loop-stick) is used. Such antennas possess a deep null in their response that usually permits the worst of these noise sources to be placed 'in the null', and so obtain a substantial improvement in signal to noise.

A significant reduction in noise may be had by making the converter self-contained and battery operated, with no electrical connection whatsoever with the AC mains (which conducts, and re-radiates noise into the shack environment). For a loop-stick antenna, a further decrease in mains-born noise pick-up is obtained where the antenna is located more than a one metre or so from mains operated devices.

Offered here is a simple, sensitive receiving converter that allows an ordinary HF receiver - one that tunes the 3 or 4 MHz bands - to be used as a 'tuneable IF'. Hence, where a signal on, for example, 137 kHz is tuned in, it will be 'up-converted' and appear on 3,137 (or 4,137) kHz.

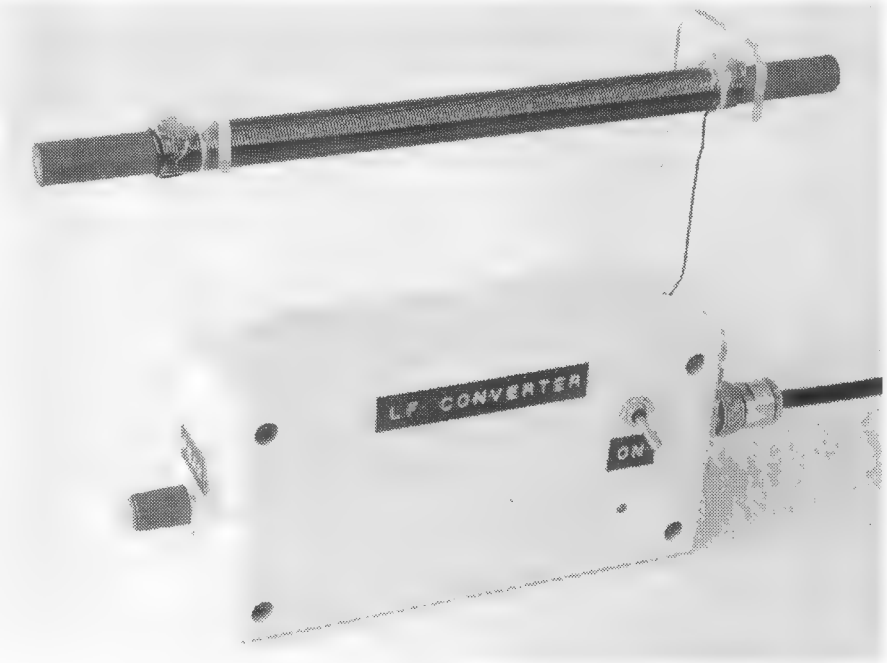

Photo 1: The LF receiving converter with loop stick antenna.

Circuit

See Figure 1. The loop-stick's self-inductance, about 2.4 mH, is resonated with a variable peaking capacitor adjustable from (about) 20 to 800 pF. This gives a tuning range of around 110 to 290 kHz, thus also providing access to some of the navigation beacon signals above 200 kHz - a handy feature for appraising the converter's capabilities.

The amount of signal energy available from a loop-stick is much less (about 20 dB) than obtained from a long wire antenna (References 1 - 6). Amplification of the loop's voltage is therefore required, partially provided in this instance by a 2N5484 FET common source amplifier. Thus, very little loading of the antenna circuit occurs, so the natural 'Q' - and hence selectivity - of the antenna is maintained. This feature greatly attenuates any (possible) intermodulation-causing signals that lie either side of the resonant frequency (a characteristic that is absent from a 'general-coverage-receiver-and-long-wire' set-up, for example). The 100 pF ceramic capacitor between gate and source discourages any strong local TV or FM signals from entering the amplifier.

A popular NE/SA602 mixer chip and on-board crystal-controlled oscillator heterodynes the LF signal up into the 3 (or 4) MHz band. The '602 also provides about 15 dB of conversion gain. A conventional broadband transformer couples the 1.5 kilohm balanced output of the '602 into 50 ohm coax cable, thence to the input of an appropriate receiver. The crystal frequency is accurately adjusted to 3.000 (or 4.000) MHz so that exact knowledge of the input frequency is assured.

Construction

The prototype model, pictured in Photo 1, is housed in a plastic 'jiffy' box measuring 130 x 67 x 40 mm. The variable capacitor, amplifier and mixer chip are accommodated upon a 'paddyboard' circuit board (Reference 7) measuring 100 x 50 mm, although any preferred construction style, even 'ugly', should serve, provided that component leads are reasonably short, and the general layout shown in Figure 2 and Photo 2 is followed.

The SA/NE602 may be fitted into an 8-pin DIL socket that is, in turn, soldered upon a 'substrate' pad of circuit board, segmented as shown. The angled cuts are at 65 degrees to the centre line of the chip. The substrate and pads may be fixed, copper side up upon the circuit

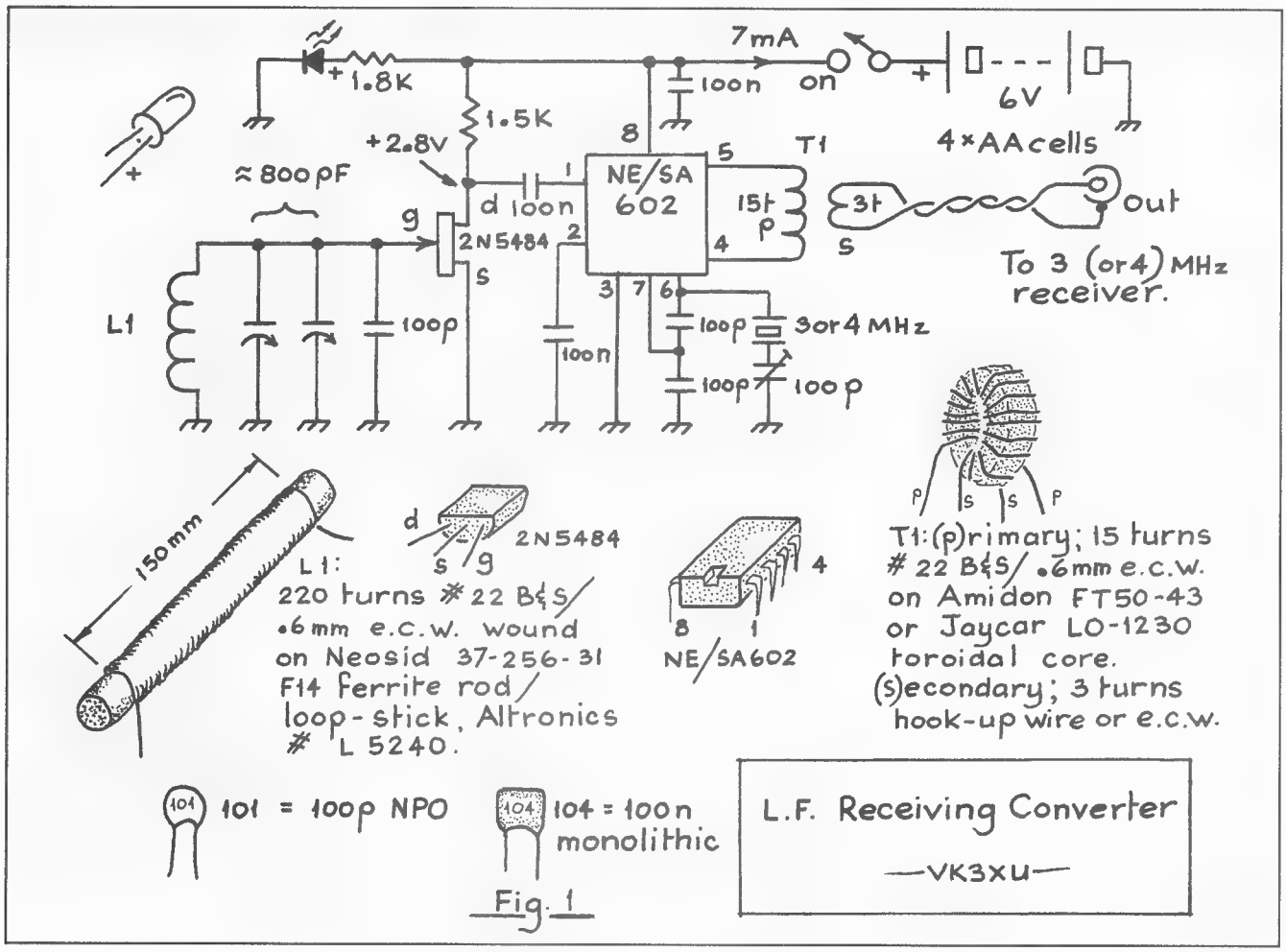

Figure 1: Schematic of the LF receiving converter.

board, with just a dab of super glue.

Or consider using hot-melt glue. In this case apply a sliver of solid glue upon the underside (fibre) of the pad, then apply your soldering iron tip to the glue and melt it evenly. Quickly place the pad on to the board in the exact spot required. A 'handle', such as a 3 A diode, may first be temporarily soldered to the pad as an aid to this procedure.

To achieve best 'Q', the loop-stick should be distanced from metal objects by more than about 50 mm. 3 mm Perspex or acrylic sheet is an ideal material for mounting the rod above the box, as illustrated in Photo 1.

For the antenna coil, close-wind 220 turns of #22 B&S/0.6 mm enamel coated wire (ecw), with a winding length about 150 mm, upon a Neosid 37-256-31 F14 ferrite rod. The coil ends may be temporarily anchored with a small piece of sticking tape. Upon final assembly, the rod is passed through a slightly over-size hole in each of the Perspex sheets. A dollop of hot-melt or epoxy glue should be applied to the interface between the coil and the Perspex. Later, with care, the tape may be removed and replaced with a small blob of glue to secure each end of the coil.

The four AA cells for the 6 V battery supply may be accommodated in a 4-cell holder (eg Jaycar P/N PH 9204), attached with hot-melt glue to the lower rear of the jiffy box.

Operation

Carefully inspect your soldering for quality and accuracy. Confirm that the FET, NE/SA602 and the 4 x AA cells are correctly installed.

Connect the converter's output to the receiver input using a suitable length of 50 ohm coax cable. Switch on, and tune your receiver to about 230 kHz (3.230 [or 4.230] MHz on the receiver's dial). Adjust the loop variable capacitor for a pronounced peak in noise, then find a navigation beacon signal, re-peaking the capacitor as you go. The set-up should sound lively (or 'gainy'), indicating that the converter is probably working correctly. You should be able to substantially reduce the (man-made) noise level by rotating the converter for lowest noise/best signal.

Now tune down to 'zero frequency' - 3 (or 4) MHz). Provided that the receiver's dial/readout is accurate, adjust the 100 pF trimmer so that the crystal oscillates on exactly 3.000 (or 4.000) MHz at 'zero beat'.

When the band is allocated to us in due course, amateur signals should be audible near 137 kHz.

Parts

All of the ordinary electronic components are available from our usual electronics component suppliers, including Altronics, Electronic World, Jaycar, Rockby and Semtronics.

The preferred Neosid ferrite rod is available from Altronics, P/N L 5240. A

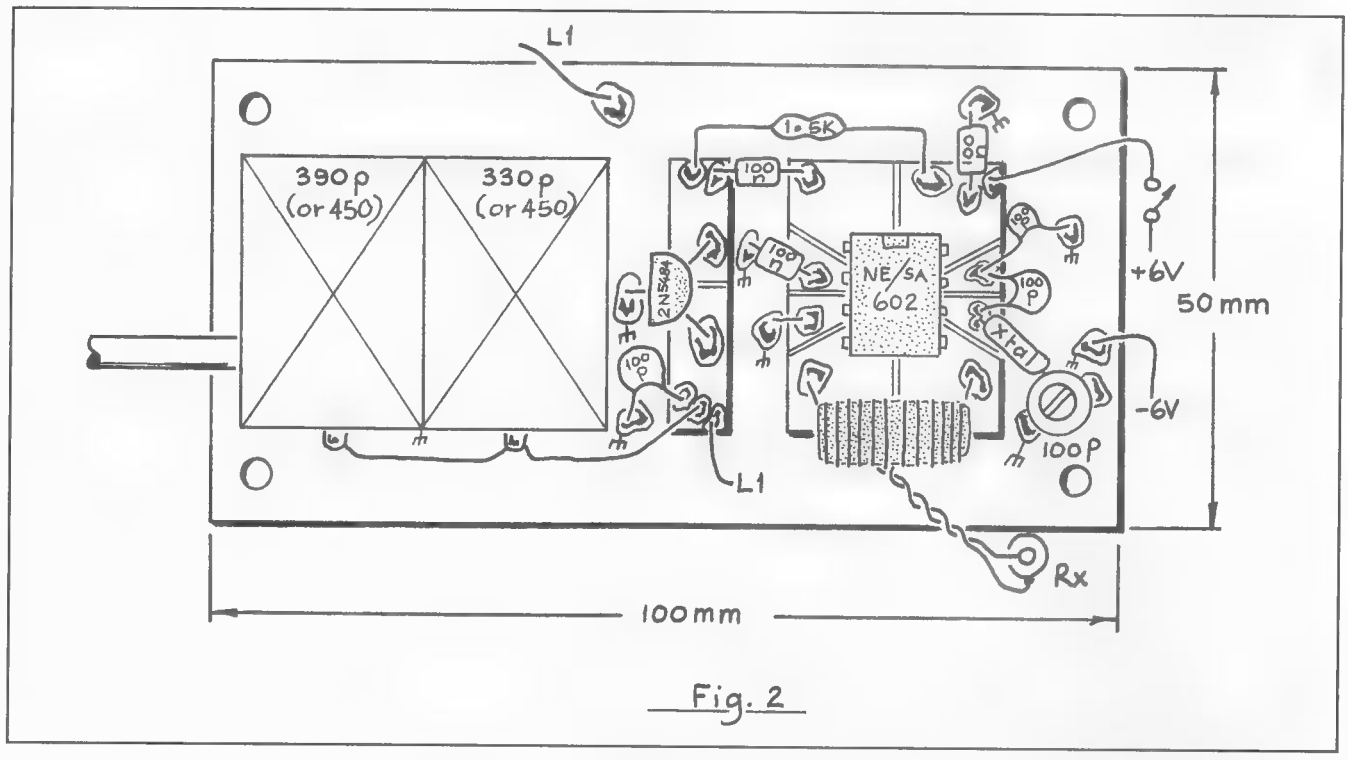

Figure 2: The general layout of the components in the plastic 'jiffy' box.

3.000 MHz crystal, P/N 13662, may be ordered from Rockby Electronics (www.rockby.com.au).

Unfortunately, SA/NE602s are not (normally) stocked by the usual suppliers (although Electronic World (03 9723 3860) have them in an SOIC [surface mount] package). Andrew Blight VK3BFA at Starlight Electronics (ph 03 9802 3421) can supply single '602s to amateurs at reasonable cost.

My plastic 'jiffy' box is a Jaycar HB 6023 (take care that your chosen variable capacitor will fit, together with the other circuitry).

The variable capacitor may be any miniature two (or three) gang broadcast type with a total capacity of 700 or 800 pF. The capacitor for the prototype (visible in Photo 2) is a beautifully made 330 + 390 pF 'Kopf' part, complete with anti-back-lash reduction drive, obtained at a local ham swap-meet at next to no cost. The fellow selling these was practically giving them away, so it is possible that you, or one of your radio mates, have one. It may be fixed upon the circuit board with four 2.5 mm (preferably brass) screws inserted into existing pre-tapped holes, where the screw heads provide four solderable anchors.

If you enjoy the same good luck as this writer, a bundle of 3 mm Perspex (acrylic) sheets may be obtainable from the off-cuts/scrap-bin at your local plastic sign makers, free for the asking.

Should you have genuine difficulty in locating an item or two, do please write (or 'phone on 039722 1620). I am not in the parts business, but I usually have spares on-hand, or can suggest a source.

References and Further Reading

1. 'The loop aerial revived'; R Schemel, *Wireless World*, July 1975.
2. *Foundations of Wireless and Electronics;* M Scroggie, p 291.
3. 'External Ferrite Aerial Units for Short, Medium and Long-Wave Radios'; R Q Marris G2BZQ, *Elektor Electronics*, May 1993 (Richard Q. Marris has written many articles about loop antennas).
4. 'A Giant LF Loopstick'; R Q Marri, G2BZQ, *QEX*, March/April 2000.
5. 'LF and VLF Converter'; R Haigh, *Everyday Practical Electronics*, July 2005.
6. *Radio Communication Handbook; RSGB*, LF chapter (10) in recent editions.
7. "Paddyboard' Circuit Construction - Revised'; *Amateur Radio*, May 2005.

Photos: Karlen Dockrey

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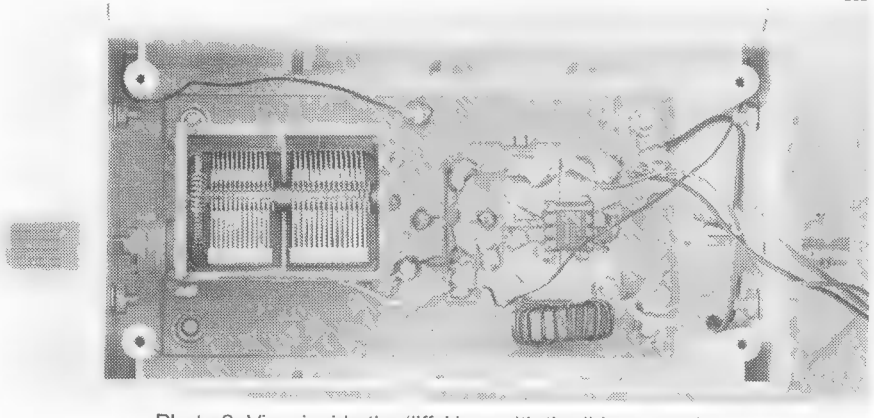

Photo 2: View inside the 'jiffy' box with the lid removed.